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**SLIDE ANNOTATION
FOR
PRESENTATION ON ICE CONDITIONS
AT MEETING OF
NORTH SLOPE SPILL RESPONSE TEAM
ON SEPTEMBER 25, 1997**

<i>Slide No.</i>	<i>Description</i>
	<u>Freeze-Up</u>
1	Ice typically starts to form in early October in the protected bays and lagoons along the Beaufort Sea coast from the Colville Delta to Camden Bay.
2	Young ice floes are very mobile and bump into each other to form circles with crunched up edges.
3	About once in every 3 years, multiyear ice invades the nearshore zone of the Beaufort Sea just prior to freeze-up. This shows a 2000' diameter multiyear floe with an embedded ridge.
4	As the first-year ice becomes thicker, the ice floes can slide over each other to form areas of rafted (layered) ice sheets.
5	Rafting occurs easily when the ice is less than 2 ft thick, but rafting can still occur occasionally when the ice reaches 5 ft thick. This shows 4 layers of rafted ice, each layer is 8" thick.
6	For about one month after freeze-up, the ice in Stefansson Sound remains extremely mobile and susceptible to large movements during storms. This shows an ice pile-up at Tern I. in 1984, created by a SW storm in October when the ice was 6" to 8" thick. After November 1, the ice in Stefansson Sound remains relatively flat in 9 out of 10 years.
7-8	These views show close-ups of the same ice pile-up as in Slide 6, with the ice blocks encroaching 15' to 20' onto the dock.
9	Very dynamic, mobile ice exists inside the barrier island chain in October. This shows Exxon's BF-37 Island in mid-October 1981.
10	Ice conditions in Stefansson Sound after a southwesterly storm in October, showing small (100' to 300' diameter) floe fragments and brash ice. No contiguous ice sheet remains.

11-13	Three-slide sequence of Seal Island during freeze-up in 1982: <u>Slide 11</u> shows ice conditions on 10/18/82 after 20-kt easterly storm. <u>Slide 12</u> shows open water conditions one day later on 10/19/82 during 40-50 kt southwesterly storm. A wind shift creates a loss of confinement for the ice and allows it to move. Note ice piled up on slope protection bags. <u>Slide 13</u> shows mid-November 1982 ice conditions, with small first-year ridges embedded in ice that has become landfast.
14	Outside of the barrier island chain in 40' to 50' water depth, the ice remains susceptible to movement longer, as witnessed at Shell's Sandpiper Island, where the 20" thick ice sheet was driven past island during SW storm on November 11, 1985.
15-16	Broken ice conditions during late freeze-up (in November) can occur as large (1000's of feet across) floes shown in <u>Slide 15</u> or as chopped up smaller (50 ft across) ice pans shown in <u>Slide 16</u> .
17-20	Even the barrier islands themselves are subject to ice movement during freeze-up, creating shoreline ice pile-ups. Cross Island is especially exposed, shown in <u>Slide 17</u> during October 1984, with a close-up of a 20 ft high ice pile-up that formed during freeze-up in 1983 and survived over the 1984 summer (<u>Slide 18</u>) and another close-up of the pile-up showing undercutting by waves and solar radiation (<u>Slide 19</u>). A 20-kt easterly in late November 1984 created a new ice pile-up at Cross Island (<u>Slide 20</u>).
21-23	Another anchoring point to reduce midwinter ice movement are the shoals north of the barrier islands from Thetis I. to West Dock. The shoals have water depths of 35 to 45 ft, located about 10-15 mi. north of the barrier island chain. <u>Slide 21</u> shows two of several rubble piles which formed on the shoals during a Christmas 1983 SW storm. They survived the 1984 summer as second-year rubble. <u>Slide 22</u> shows a close-up of the 40 ft high, 2000 ft long rubble, but very little additional rubble was generated during the 1984 freeze-up. <u>Slide 23</u> shows a new rubble pile being created during November 1985 on a shoal in 46 ft of water.
	<u>Winter</u>
24	By the mid-December when the ice thickness is 2 to 2.5 ft, most of the offshore region in less than 40 ft of water becomes landfast for the remainder of the winter. The landfast ice may contain embedded multiyear floes and ridges as shown here.
25-26	The shear zone (boundary between the landfast ice and the pack ice) is well-established by mid-December, as shown in <u>Slide 25</u> . The pack ice offshore of the grounded shear zone remains free to move east-to-west about 6-8 mi. per day throughout the winter (<u>Slide 26</u>). Winter ice conditions typically last from mid-December to late June. In late May and through June, any lead that may open offshore of the shear zone will remain open and not refreeze.

	<u>Break-Up</u>
27-28	In late May local rivers, such as the Colville, Kuparuk, Sag, and Canning Rivers, start to flow and overflow the ice offshore of the deltas out to the 20 ft water depth. During the overflow, the water flows over the top of the landfast ice and drains through the ice in cracks and holes as shown in <u>Slide 27</u> . Sediment may cover the ice in the overflow zone, except where the swirling water from the draining action keeps the ice swept clean (<u>Slide 28</u>).
29	By mid-June the dirty, warmer water has melted the ice in the overflow zone and elsewhere many melt ponds have occurred in the landfast ice. Thermal and tidal cracks are open.
30	Break-up of the landfast ice in Stefansson Sound occurs in late June or early July.
31	The broken ice floes can move back together creating thick, but deteriorated, rafted ice.
32	Seal Island ice road breaking into fragments on July 10, 1983.
33	A SW wind in early July 1984 created a 25 ft high ice pile-up at Tern Island.
34-35	During break-up, ice ride-up can occur on the barrier islands, as shown in <u>Slide 34</u> . The unfrozen gravel is frequently plowed up into berms by ice ride-up events during break-up (<u>Slide 35</u>).
36-40	The unprotected shoreline in Camden Bay is susceptible to ice ride-up and pile-up during freeze-up and break-up. <u>Slides 36-37</u> show a 30 ft high, old 1983 freeze-up ice pile at Collinson Pt. in late June 1984. During the observations, an ice ride-up event occurred with 3 ft thick ice blocks moving ashore (<u>Slide 38</u>) and piling up against the old freeze-up ice pile-up (<u>Slides 39-40</u>).
41-42	As break-up progresses rapidly inside the barrier islands and offshore to 30 to 40 ft water depths, further offshore multiyear floes start to deteriorate (<u>Slide 41</u>) and break up (<u>Slide 42</u>).
43	In mid-to-late July the grounded shear zone starts to break up into large rubble fragments.
44	The grounded rubble piles on the shoals north of the barrier islands were in open water at the end of July 1984.
	<u>Summer</u>
45-48	The summer season is typically 75-80 days long, with mostly open water, but one or more ice invasions can occur. This series of slides shows Seal Island in the early summer 1984: <u>Slide 45</u> shows the ice conditions on July 8, just after break-up. <u>Slide 46</u> shows 8-9 tenths broken ice on July 17. <u>Slide 47</u> shows only 1-2 tenths broken ice the next day on July 18 during an easterly wind. <u>Slide 48</u> shows an ice invasion of about 5 tenths broken ice on July 22.